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MBA PROFESSIONAL REPORT

Cost Comparative Analysis of Blast Mitigation Technologies with Regard to Explosive Remnants of War (ERW)

By: Paul J. Mahoney

December 2011

Advisors: Brad Naegle
Raymond Buettner

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13. ABSTRACT *(maximum 200 words)*

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COST COMPARATIVE ANALYSIS OF BLAST MITIGATION TECHNOLOGIES WITH REGARD TO EXPLOSIVE REMNANTS OF WAR (ERW)

Paul J. Mahoney, Lieutenant, United States Navy

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
December 2011

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ABSTRACT

The purpose of this MBA Project is to investigate and analyze different forms of blast mitigation technologies that provide safe temporary storage, and in the event of a detonation, provide protection measures for personnel and property. A comprehensive cost comparison of an Explosive Storage Magazine (ESM) and two alternatives: the Explosive Remnants of War Collection Point (ERW-CP) and Blastwrap are analyzed to determine future options. The goal of this project is to identify and document both cost comparisons, as well as requirement satisfaction for the safe and cost-effective temporary storage in troubled regions around the globe.

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Professor Brad Naegle

Professor Raymond Buettner

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EXECUTIVE SUMMARY

The purpose of this MBA project is to determine what nonrecurring and recurring costs, resulting from a conventional means of explosive storage, and to examine the practicality of implementing conventional explosive storage in a semi / nonpermissive environment to help facilitate the safer collection of hazardous ordnance items in villages and towns around the world. The second objective of this project is to compare two relatively new and ecologically friendly forms of explosive storage with those of conventional means and to ascertain whether, in fact, the benefits provided by this new technology are more cost effective and whether they provide similar or greater benefits to the intended villages. Finally, once the data has been compared and weighed, this study will provide a recommendation as to which system is better suited for semi / nonpermissive environments.

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I. EXPLOSIVE REMNANTS OF WAR (ERW): THE PROBLEM

A. ERW

Explosive remnants of war are left-over pieces of ordnance in countries all over the world that remain on the soil of these countries for years, if not decades before they are eventually discovered by someone during reconstruction of the area. Sometimes, personnel stumble upon various items such as artillery shells, grenades, or even various forms of cluster munitions. These are all extremely dangerous to handle, if one is not familiar with the functioning of these various devices. During postconflict, these items are slow to be disposed of and even more costly when the conflicting parties may no longer have the economic resources to support such disposal operations. For these reasons, ERW are a global problem that many nations and the United Nations acknowledge and for which they commit resources to help correct the problem. With the current conditions of the world economies, it is essential to try to evaluate the best solution that will provide the most benefit for the lowest acceptable cost.

The difference between ERW, Unexploded Ordnance (UXO), and abandoned ordnance must be clarified Per the United Nations Convention on Conventional Weapons (CCW) Article V on Explosive Remnants of War: (Geneva International Centre for Humanitarian Deming, 2004)

1. UXO

Explosive ordnance that has been primed, fused, armed, or otherwise prepared for use and used in an armed conflict (Geneva International Centre for Humanitarian Deming, 2004). It may have been fired, dropped, launched or projected and should have exploded, but failed to do so.


Figure 1: UXO Disposal in Iraq (From Wikipedia, 2003)

2. Abandoned Explosives

Explosive ordnance that has not been used during an armed conflict, that has been left behind or dumped by a party in an armed conflict, and which is no longer under control of the party that left it behind or dumped it. Abandoned explosive ordnance may or may not have been primed, fused, armed or otherwise prepared for use (Geneva International Centre for Humanitarian Deming, 2004).

Together, UXO and abandoned explosives comprise ERW as defined by the United Nations and the current 69 states that are bound by this protocol from the CCW (Geneva International Centre for Humanitarian Deming, 2004).

B. CURRENT METHODS OF DETECTION AND CLEARANCE

Detection

The current capabilities to detect various ordnance items consist of using costly detection equipment and methods that require an immense amount of time. Within stable and secure countries like the United States and most countries in Europe, such methods are more practical and using methods and technology such as multiple metal detector arrays to locate ferrous and nonferrous objects underneath the ground may be practical.

However, in countries like Afghanistan, Laos, and the Philippines most methods of detection occur by the random chance of stumbling upon such objects from either from construction projects in previous war-torn areas, or just walking through fields or other areas where conflict may have occurred (Geneva International Centre for Humanitarian Deming, 2003).

Figure 2: Afghan Detecting and Clearing Landmines (From Villano, 2009)

Clearance

Once these hazardous objects are located, it may be impractical to move the ERW due to its current unknown or unstable condition. Some pieces of ordnance may be exuding explosive residues and mere contact could cause a high order detonation. Other times, fuses may be deteriorated and in such a state that the ordnance is essentially ready to detonate and—merely waiting for the right signal. For this reason, clearance should always involve trained and qualified personnel to assist. Most of the qualified personnel come from the over 42 demining programs[1] established all around the world to assist in the manual clearance of landmines.

Many villagers in troubled countries around the world handle these pieces of ordnance without the requisite knowledge and training, and could be putting themselves as well as other personnel in serious jeopardy (Personal experience of the author, 2010). The intent of villagers who are trying to clear the problem themselves and keep their

[1] Executive Summary Manual Mine Clearance Book, 1.

community safe, is a good thing, but can have serious consequences. Training enough people in the techniques of explosive ordnance disposal (EOD) and supplying them with the necessary tools is not cost effective and could have potential security concerns with the distribution of such knowledge. Only through education and a cost-effective forms of technology will this hazard be effectively mitigated and, at the same time, provide villagers with a trade that they can use in and around their community.

The best option for villagers in these hostile environments would be to store these hazardous items in a secure and cost-effective containment system. Securing these items in a storage container at a safe distance away from the village until qualified personnel are able to dispose of the ordnance properly and safely is the best option for areas where resources are scarce.

II. CONTAINMENT SYSTEM OPTIONS

This research examines three possible options for temporary containment and blast mitigation systems that provide portability, cost effectiveness, and ease of set up and maintenance, and blast containment / mitigation characteristics. The three types of candidate solutions for containment / mitigation are detailed below and include a standard explosive storage magazine (ESM), a BlastGard blast mitigation device, and an explosives remnant of war collection point constructed from papercrete and other locally sourced materials. All of these systems provide a stable form of storage for ERW, and it should be noted that if a detonation should occur in any of these systems, they would be damaged beyond repair and reusing any of them would either be impossible or impractical.

The ESM is essentially the standard for explosives storage in countries like the United States where the laws are very strict regarding how one can safely and securely store hazardous devices and materials. Some commands assisting these afflicted regions may choose to exercise a similar option by purchasing such an item and placing it in a village. Although the requirements will meet or exceed those governed by U.S. authorities, the logistics and practicality of placing such an item in a village in Afghanistan, for example could prove challenging from the point of view of transporting the ESM by ground or air.

A. EXPLOSIVE STORAGE MAGAZINE

The ESM this research uses, as a baseline is the advanced EOD storage magazine, manufactured by Armag Corp.

Figure 3: Advanced EOD Storage Magazine (From Armag Corporation, 2011)

The advanced EOD storage magazine is a four-foot by four-foot by four-foot steel box. The magazine is rated to store approximately ten pounds net explosive weight (NEW) with a maximum credible event (MCE) of zero (Armag Corporation, 2006). This magazine is designed for outdoor use while the majority of magazines are designed for indoor use. Per the Bureau of Alcohol, Tobacco, and Firearms (BATF), outdoor magazines must be cleared 25 feet in all directions of debris, trash, and other brush that is less than ten feet tall (Bureau of Alcohol, Tobacco, Firearms and Explosives, 2011). In addition, any volatile materials must be kept at least 50 feet away from the magazine. These ESMs are easily purchased through the U.S. General Services Administration (GSA) and range in price from several hundred dollars to several thousand dollars, depending on dimensions and features (Clark, 2011). The advanced EOD storage magazine pictured carries a price tag of $3,989.70 (Clark, 2011).

B. BLASTGARD INC. BLASTWRAP

The second product examined is Blastwrap. Blastwrap is a material that resembles bubble wrap, but each of the individual cells contains a mixture of fire extinguishing materials and perlite (Blastgard International, 2008). Perlite is a volcanic glass that, when heated, causes expansion of the material from seven to sixteen times its original volume. During the expansion process, it absorbs much of the blast impulse from the detonation and, at the same time releases the trapped water, helping to extinguish the fireball (Svensson, 2005). The current U.S. GSA price for Blastwrap is $71.25 per square foot.

Figure 4: Blastwrap (From Popular Science, 2005)

C. EXPLOSIVE REMANTS OF WAR COLLECTION POINT KIT

Finally, the ERW-CP kit will be examined, including its feasibility to compete with the two commercial options described above. The ERW-CP kit consists of a 55-gallon drum that contains instructions on how to create a structure that is safe for the temporary storage of explosives until qualified personnel can arrive. These personnel can then properly dispose of the ordnance collected around the village or area in question. The main structure is built from papercrete, which is a locally sourced material. This kit contains minimal equipment from a weight perspective and minimizes the cost of commercial off the shelf (COTS) components. These factors allow for stimulation of the local economy to further help the country with the munitions contamination problem of ERW.

Papercrete is essentially part Portland cement and an aggregate of recycled paper or other cellulosic-based material and other additives, if desired. The recycled paper is an easily procured item that can be any form of paper or cellulosic material (Wikipedia, 2011). The paper is processed into a hammer mill to grind the paper to a fine grain size, which allows for a homogenous mix with the Portland cement. A solar charging kit that comes with the ERW-CP kit allows for an environmentally friendly solution that powers the hammer mill. In addition, the solar charging kit also powers a direct current motor that is used to mix everything in the 55-gallon drum.

While the papercrete is being mixed, other personnel can begin setting up the form that the mixture will be poured into. The form is assembled from materials that come inside the kit. Two cylinders are set up vertically and reinforced with soil from the surrounding area. The papercrete is poured and the center is hollowed out to allow for the storage of hazardous devices. Once the papercrete has properly cured, which can be heavily dependent on weather conditions and terrain, the form materials can be removed and reused, if undamaged, to create other ERW-CPs.

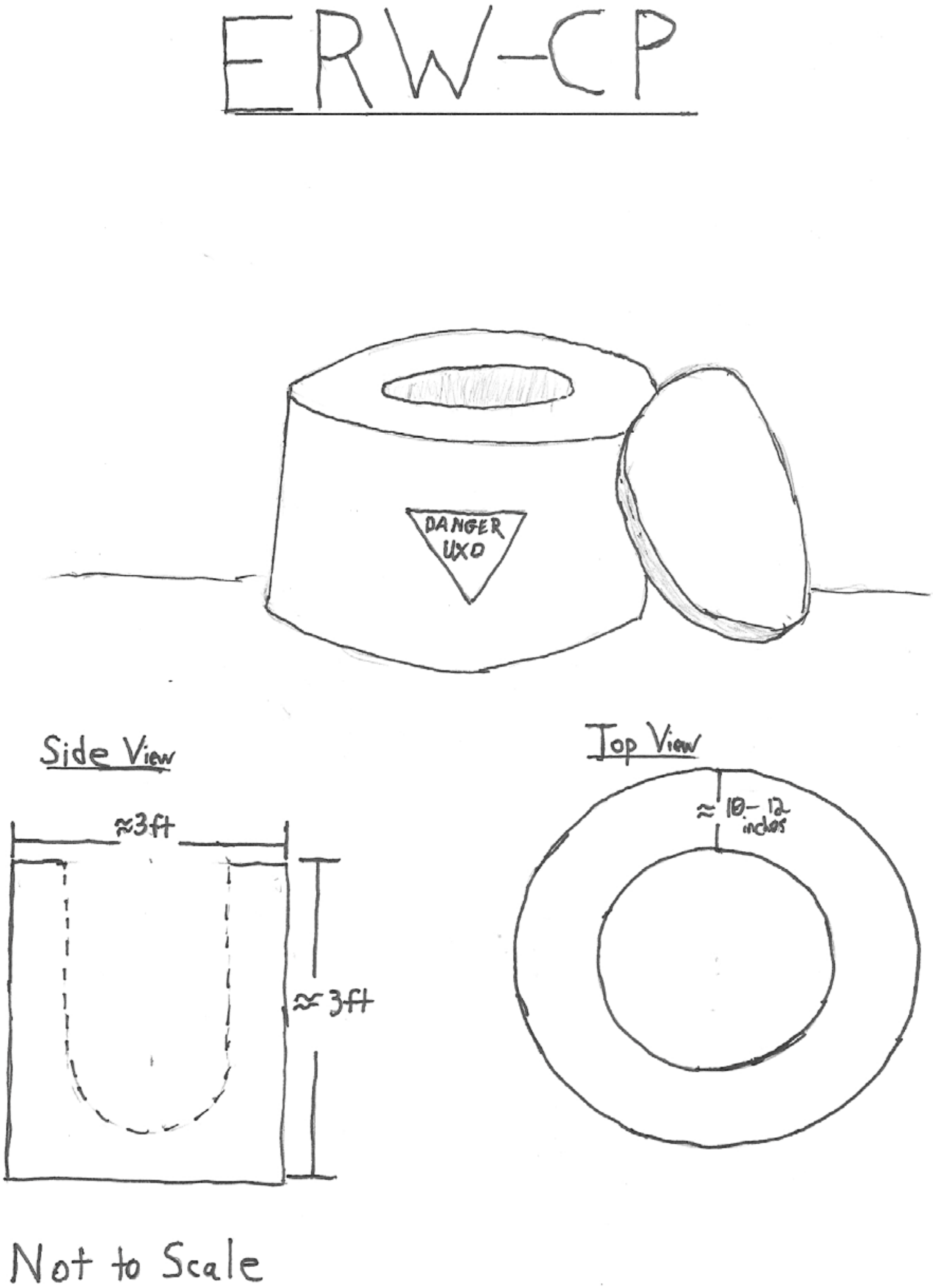

Figure 5: ERW-CP Basic Design

D. SCIENCE OF BLAST EFFECTS

Understanding the physical and chemical reactions of what transpires during a detonation is essential to understanding how these products provide safety for personnel in a surrounding area. Everyone has seen an explosion at some point in their lives, whether in real life or in a movie. However, most people do not understand the nature of what is really going on during the event. Explosive materials come in all shapes, sizes, and various chemical compositions. Once an understanding of the detonation event is obtained, people can begin to decipher the quantitative and qualitative measurements from that event and emplace practical technologies that will contribute greatly to safety. Understanding the basic science allows personnel to develop and test methods such as the technologies stated above to aide in the containment and blast mitigation of ERW.

When an explosive material detonates, the material undergoes a rapid chemical reaction, transforming into a volume several orders of magnitude greater than the original volume of the explosive material. When a detonation of high explosives occurs, several things happen. First, peak air pressure increases dramatically, creating a shock wave front (Naval Explosive Ordnance Disposal Technology Division, 1998). Once this shock wave is created, it begins to move outward in a generally omni-directional fashion from the point of detonation. As soon as the temperature begins to drop, and the blast wave begins to decay, the wave degenerates into a typical sound wave (Naval Explosive Ordnance Disposal Technology Division, 1998). The airflow begins to reverse direction, creating a temporary negative phase, until conditions quickly return to normal atmospheric conditions. Below is a graph that depicts the atmospheric phases of a detonation over the period of time for the event.

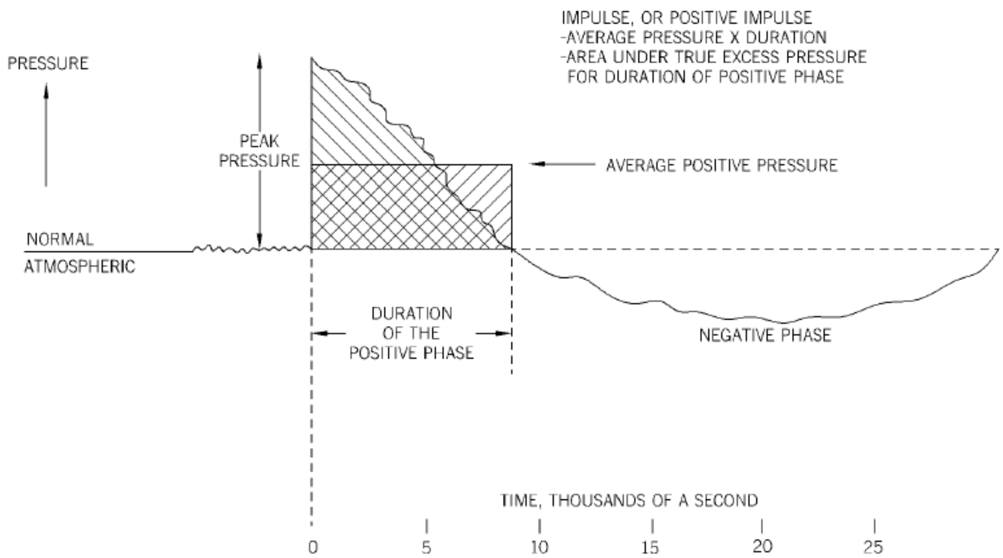

Figure 6: Blast Wave Characteristics (From Naval Explosive Ordnance Disposal Technology Division, 1998)3

Now that the characteristics of blast overpressure are understood, the secondary effect of fragmentation must be explained to fully understand the ERW in question. Fragmentation is the secondary effect of a piece of ordnance detonating and is literally the fragments of the case that the explosive material was housed (Naval Explosive Ordnance Disposal Technology Division, 1998). Casing for munitions can be subdivided into light and heavy cases. Light casing is defined as having 80 percent of the total munitions weight in explosive material, or the main charge (Naval Explosive Ordnance Disposal Technology Division, 1998). Heavy casing is simply having munitions where the explosive material weight is less than 80 percent of the total munitions weight (Naval Explosive Ordnance Disposal Technology Division, 1998). All of this information is incorporated to develop the equation:

$$D = K \times \sqrt[3]{W}$$

Where D is the distance in feet or meters for a given pressure per square inch (PSI) value, K is the K-Factor for a given PSI value or a safe fragment distance, and W is the total weight of TNT or its equivalent.

The K-factor is used to help determine the minimum safe distances for the area required for the three different technologies mentioned above. K-factor tables have been developed to reliably plot and determine the expected PSI value that would be experienced from a detonation at various distances from the point of detonation (Naval Explosive Ordnance Disposal Technology Division, 1998). For the purpose of this research project, we will consider K to be 30 as the factor for determining distances for safe temporary storage.

At a K-factor of 30, the blast overpressure would be approximately two PSI (Naval Explosive Ordnance Disposal Technology Division, 1998). Human blast tolerances can have large variances, depending on the amount of explosive, type of explosive, and the duration of the explosion. Human blast tolerances for explosive durations ranging from three to five milliseconds have been recorded for the various critical gas-filled organs that would be most susceptible during an explosion (Naval Explosive Ordnance Disposal Technology Division, 1998). The pressure threshold for lung damage is between 30 and 40 PSI with severe lung hemorrhaging at 80 PSI (Naval Explosive Ordnance Disposal Technology Division, 1998). At a K factor of 30, the only major blast overpressure hazard is temporary eardrum damage, which occurs at .2 PSI, resulting in temporary hearing loss (Naval Explosive Ordnance Disposal Technology Division, 1998). This is an acceptable risk because to achieve a K factor of 300, which is the value where the PSI level would be .07 PSI, would require too much distance between a village and storage site, while still requiring an adequate amount of security.

III. HYPOTHESIS

A. COST COMPARATIVE ANALYSIS:

The hypothesis for this cost comparative analysis is that Blastwrap may be a more cost-effective solution because it is already on the commercial market. Although it is a high cost per square foot alternative, economy of scale may bring the price down to more affordable levels. From a purely cost perspective, Blastwrap is ready now and users could purchase mass quantities of Blastwrap and secure it to the inside of a metal cylinder such as old-style trashcans or empty 55-gallon drums.

However, the benefit of the ERW-CP kit is not only blast mitigation and as a temporary storage structure, but also a trade that can be learned in constructing papercrete building materials, a skill set that could be used to construct other structures. It may also allow local economies to be stimulated to help benefit everyone. The dual-use nature of this system, compared to the others, may prove to make the difference in the end.

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IV. COMPARATIVE ANALYSIS OF BASELINE AND ALTERNATIVE OPTIONS

A. ESM BASELINE

1. ESM Nonrecurring Costs

The ESM is the standard for explosive storage and containment and the cost associated with that system is the up-front capital investment of $3,989.70 for each ESM. This does not, however, include the cost of transportation of the system to its intended destination. Delivery within the United States costs another $1,459.00. The system would then have to be transported to an overseas area by ship or aircraft. Although this would be completed through the U.S. Government, there is still a cost associated with transportation to the afflicted area. The estimate in this model, for the hidden cost, will be $3,000 for transport by aircraft, due to the size, weight, and flight hours, to the intended destination. Once in the afflicted country, the estimated cost for ground transportation is $2,000. U.S. personnel would perform setup of the ESM in the village, on the ground, while conducting village support operations (VSO). U.S. members would then be responsible for training indigenous personnel in proper maintenance and handling of dangerous items for temporary storage until EOD personnel arrived at the village for proper disposal.

Nonrecurring Cost:

- One ESM $3,989.70
- Delivery to U.S. receiving area $1,459.00
- Air Transport $3,000.00
- Ground Transport $2,000.00

TOTAL Nonrecurring Costs: $10,448.70

2. ESM Recurring Costs

Recurring costs for the ESM will be estimated using a marginal cost model, limited to the training of U.S. personnel as units redeploy and deploy from the region. In addition, training and retraining for indigenous personnel will happen from time-to-time as people come and go from the village. It is difficult to place an "actual" cost for training. For purposes of this analysis, estimates for training costs will be the number of training hours U.S. personnel spend training indigenous personnel. Using the current monthly pay tables for U.S. military personnel and dividing it by the number of logged hours units spend training villagers, we can assume a rough estimate of the tax dollars spent.

Recurring Costs:

(E5 base pay X 3) X (O3 base pay) / Hours of training completed per month = dollars / month

The formula above is an estimate using an E5, which is an enlisted person in his fifth pay grade; for example, an E5 in the U.S. Army is a sergeant. The O3, a captain in the U.S. Army, is a military officer in his third pay grade.

Maintenance for the ESM will be limited to general maintenance and inspection of materials to ensure cleanliness and to monitor the degradation of materials, i.e., corrosion. Due to the material makeup and construction of this ESM, its lifecycle will likely be several decades. Security training will also be recurring until the village can self-sustain and U.S. presence is no longer required. Security with an ESM does not need to be as in-depth as the alternatives, since the ESM has an exterior of one-quarter inch-thick steel with a high security hasp lock.

3. ESM Nonrecurring Benefits

The main nonrecurring benefit, as with all the alternatives in this analysis, is that if a detonation does occur, the system will no longer be a viable option for explosive storage. However, the value in potentially saving the lives of U.S. personnel and villagers is tremendous, not only for the impact on families and friends, but because the

productivity of that individual is not lost or degraded. Losing a life degrades the labor force, adding an additional labor burden on the remaining individuals.

Along with the lifesaving capabilities, a detonation within the confines of an ESM would reduce collateral damage to the surrounding structures or property that may be in the vicinity of the magazine. This is a non-quantifiable benefit due to the amount and type of explosive ordnance that may be contained in the ESM, as different types of explosives can be more damaging than others.

4. ESM Recurring Benefits

The recurring benefits of an ESM include explosive device decontamination for greater utilization of agricultural land and the further expansion of construction projects in and around villages. As explosive device decontamination continues, incidents involving unintended detonation would decrease, decreasing the need for emergency medical treatment and allow non-governmental organizations (NGOs) easier access to afflicted areas to assist with other issues afflicting a village. With less explosive material in the area, the likelihood of terrorists and insurgents acquiring materials for IED construction would also be reduced.

B. BLASTGARD INC. BLASTWRAP (ALTERNATIVE ONE):

1. Nonrecurring Costs

The nonrecurring costs of Blastwrap include the initial capital investment and deployment to the afflicted areas. Setup is minimal, consisting of cutting strips to desired lengths to line the inside of the trashcan or other receptacle. The strips can be secured in place with a fast-setting adhesive, and the materials themselves are lightweight, which makes for easy transportation.

Nonrecurring Cost:

- Blastwrap two inch-thick package in strips (40.5 inches x 10 1/8 inch wide): 2 X $71.25 = $142.50

- 55-gallon industrial plastic trash cans: $55.00

- 5-gallon 3M Fastbond insulation adhesive 49: $290.00

- Air transport: $2,000.00

-Ground transport: $1,000.00

TOTAL Nonrecurring costs = $3,487.50

2. Recurring Costs

Recurring costs for the Blastwrap system would have similar costs, such as training and regular maintenance. However, it should be noted that training and maintenance would be drastically reduced in comparison to the ESM. Security training, to ensure only authorized personnel are accessing these explosive items, would be the most intensive training required with this system. Increased security will have to be maintained since there is a significant trade-off in physical security with regard to the access of a plastic container, compared to a steel box with a high-security hasp lock.

Added security measures will require additional training hours in anti-terrorism force protection (AT/FP) for the area. Along with added AT/FP, the villagers will need to train in various techniques of explosive identification and handling to ensure maximum safety is achieved. Again, estimated training costs can be computed through the simple model stated above in the ESM section.

3. Nonrecurring Benefits

The benefit of the Blastwrap system is that its several orders of magnitude lighter than the ¼ inch steel ESM and has an innovative solution with regard to blast mitigation. The nonrecurring cost savings of $6,961.20 per unit alone make this a very attractive solution in an environment with constrained budgets in harsh economic times.

The ESM will have to be a stand-alone, outdoor, temporary storage with no electrical systems, fire suppression devices, or environmental control systems. In this environment, Blastwrap's individual cells are made up of an eco-friendly fire retardant combined with the perlite volcanic glass, which provides a remarkable fire suppression capability. In the event of a detonation, Blastwrap provides protection against secondary fragmentation and, in essence, will not become part of the problem if the worst does

happen. The ESM could produce secondary fragments due to its steel exterior, given a sufficient quantity of explosive material stored within.

4. Recurring Benefits

One of the major recurring benefits of Blastwrap is the ease of deployment and follow-on of additional units if desired or needed. Although it is difficult to quantify these benefits in a dollar amount, the lifesaving capability of this technology is significant, and the drastically improved quality of life of those affected with explosive device contamination provides an additional significant benefit.

C. ERW-CP (ALTERNATIVE TWO)

1. Nonrecurring Costs

The nonrecurring costs associated with the ERW-CP have a minimal amount of capital investment, comparable to those of Blastwrap. Deployment of the kit is as easy as placing a 55-gallon drum on a pallet and shipping it to the afflicted area. Setup of the ERW-CP can take substantially longer than Blastwrap since it can take, on average, three weeks for the papercrete to set properly, depending on the environmental conditions. In the event of a detonation, the structure will be damaged to the point that it will either have to be rebuilt or repaired using another preparation of papercrete to the affected areas inside the unit..

Nonrecurring Costs:

- ERW-CP kit: $2,937.95
    - 55-gallon drum: $77.95
    - Solar Power Station: $1,500.00
    - Other Kit Materials: $1,360.00
- Air transport: $2,000.00
- Ground transport: $1,000.00

TOTAL = $5,937.95

2. Recurring Costs

Depending on the type and amount of explosive contamination in the area, the only direct recurring costs should be the purchase of locally sourced raw materials to construct ERW-CP. Indirectly, the training, by U.S. persons, of personnel in and around the village on the use of ERW-CP's and the security that should be in place for these hazardous items is the only recurring cost.

3. Nonrecurring Benefits

The primary benefit for the ERW-CP is the blast mitigation it provides by directing the blast energy upwards and away from personnel and property. Another direct benefit that it is designed to catch the primary fragmentation that is produced during the detonation of small to mid-size projectiles or other explosive devices.

The cost savings of the ERW-CP, compared to the ESM baseline, is $4,510.75 and although this is $2,450.45 less than Blastwrap, Blastwrap does not have any uses other than blast mitigation.

4. Recurring Benefits

The recurring benefits of this innovative design in blast mitigation far exceed those of any other technology or technique available in the commercial market. Papercrete engineering is a real trade that can be taught to indigenous personnel with minimal cost and, at the same time, may stimulate local economies in the afflicted area to help develop infrastructure using the same techniques, all while providing an ecological solution to the environment. Papercrete, as a material, is heavily composed of cellulosic substances, using recycled paper or other plant life, such as tree bark, saw dust, or any other cellulose-based material, makes the impact to the environment minimal.

Along with the kit's intent to minimize carbon emissions, it comes with a solar power source used to power the equipment to make the papercrete. The solar power supply can be used for other projects in and around the village. The design of the kit was

built around the idea that everything in the kit should have a dual-use purpose. This is where the recurring benefits of the ERW-CP far outweigh those with the ESM or Blastwrap.

Although it is difficult to quantify the qualitative nature of this recurring benefit, care should be given to considering the economic gains a village or nation may acquire from opening up such a market. Papercrete can be used and is intended for domestic construction in the country it is deployed to. Papercrete can be fashioned into walls or bricks for domicile construction (Hart, 2001). Papercrete is dimensionally stable when taking in water and drying out. Papercrete will absorb moisture if it rains or if the climate is very humid (Hart, 2001). In addition, the material is fairly fireproof, with only minor smoldering effects if the papercrete catches fire. The only thing that may be required is a water-repellant paint or coating to keep moisture out if the environmental conditions are unfavorable for curing.

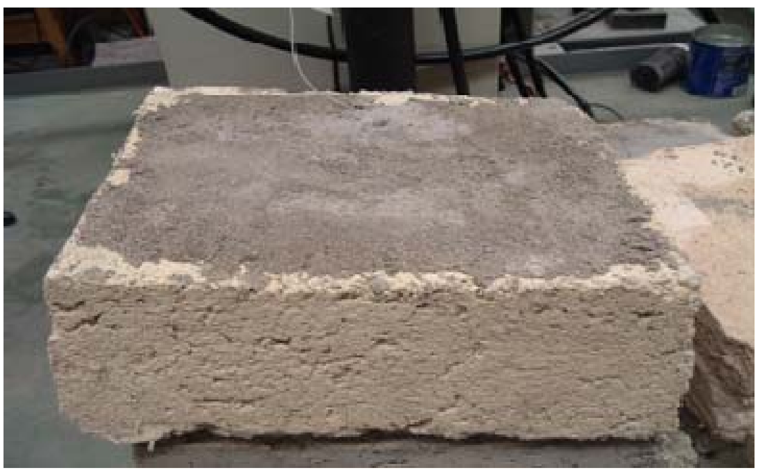

Figure 7: Papercrete Block with Mortar (From The Center for Alternative Building Studies, 2005)

D. ESTIMATES FOR DEPLOYMENT OF ALTERNATIVES TO AFGHANISTAN

For one of the biggest problem areas for ERW in the world today, Afghanistan, estimates of the two alternatives will be calculated to determine an approximate quantity

of units required to help mitigate the problem within the country. There has been numerous data over the past ten years on ERW within Afghanistan, and using that information will help in the estimate.

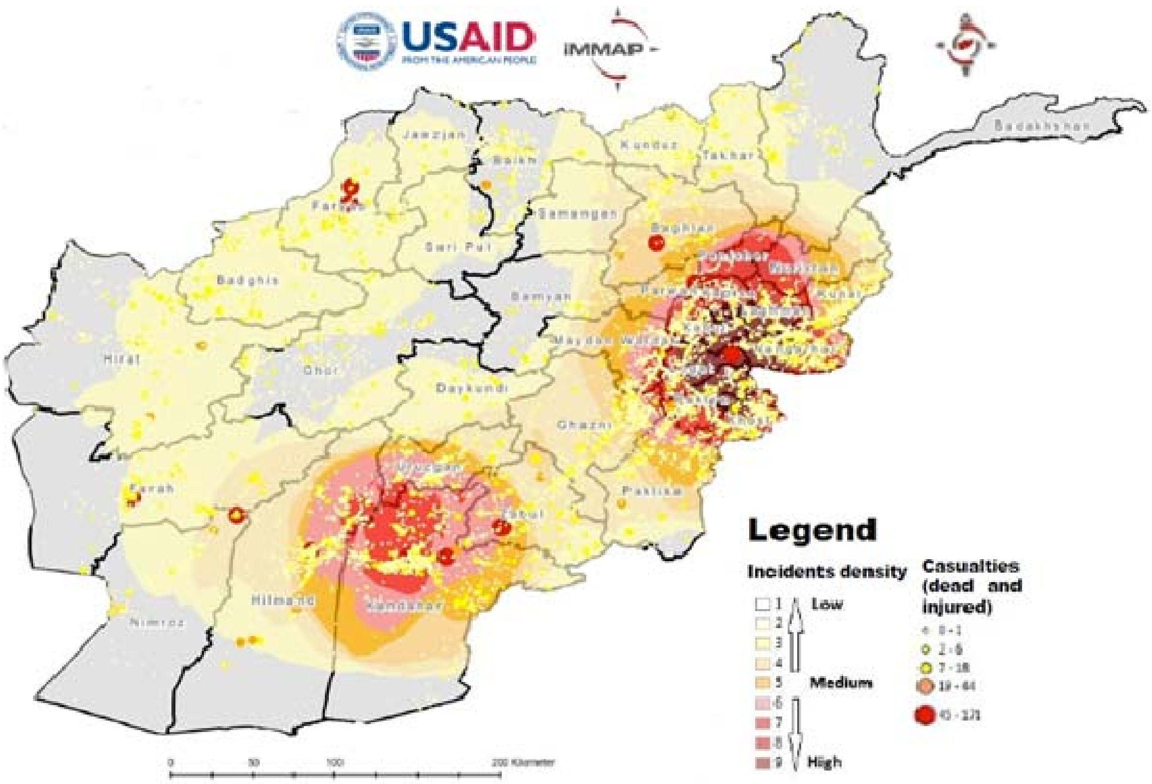

Figure 8: Afghanistan Incidents Map from 2008–2011 (From iMMAP, 2011)

The number of incidents in Afghanistan is substantial over this brief four-year period. Figure 8 helps give a visual representation of the issue at hand there. More detailed information is provided in the two graphs below.

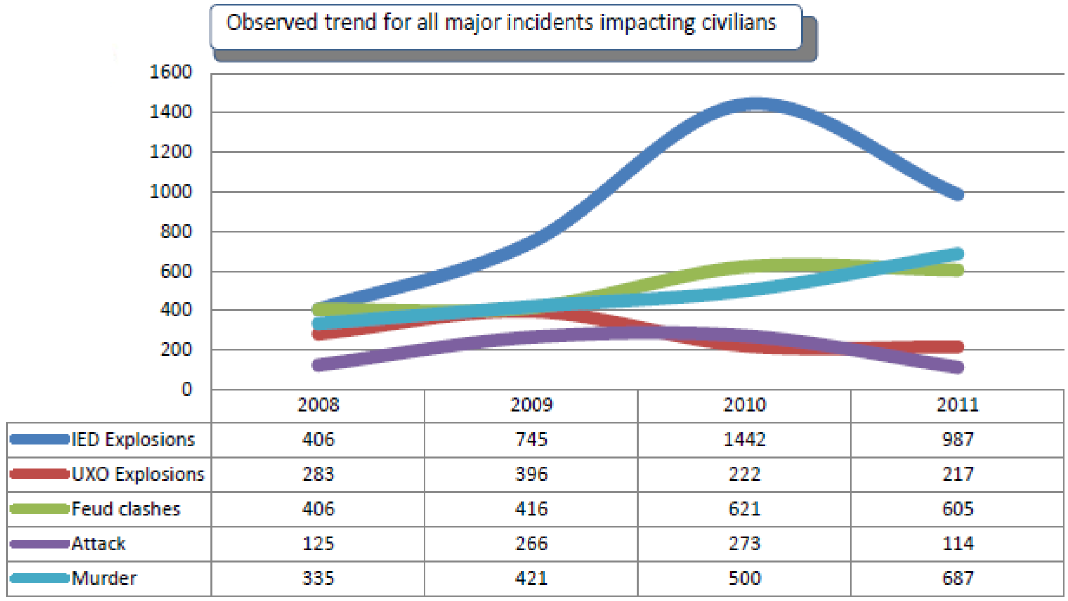

Figure 9: Trends of IED and UXO Explosions in Afghanistan from 2008–2011 (From iMMAP, 2011)

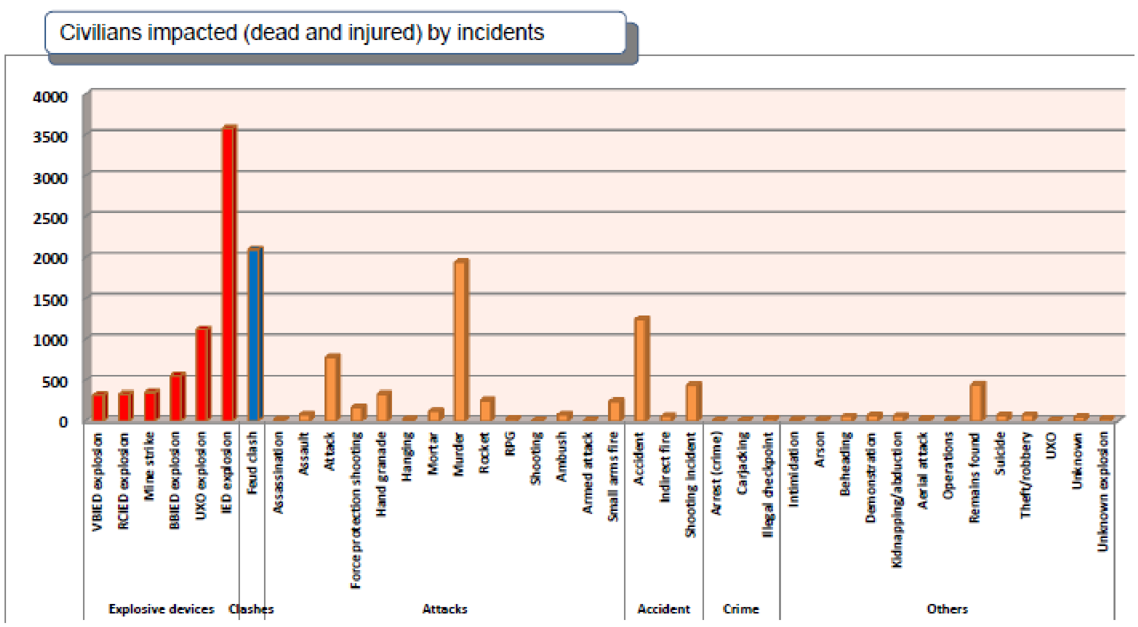

Figure 10: Civilian Casualties, by Incidents, in Afghanistan from 2008–2011 (From iMMAP, 2011)

From the data, a total of 4,698 explosion events have occurred between 2008 and 2011, and of those events, approximately 3,500 civilians have been killed or seriously injured (iMMAP, 2011). Without a doubt, some of these events could have been prevented through the use of Blastwrap or an ERW-CP. The current human cost of this contamination is, on average, 40 Afghans killed or injured every month due to ERW (E-MINE (Electronic Mine Information Network, 2011). Lost access to large quantities of productive land for livelihoods and settlement only serve to reinforce poverty, destabilize communities and undermine opportunities for development (E-MINE [Electronic Mine Information Network], 2011). We will assume that 40 ERW items per month are found and over the course of a year, we will estimate 480 pieces of ERW are discovered within Afghanistan.

1. Blast Wrap Estimate

With a total of 480 items found within a year, the ordnance item for the purpose of this estimate will be estimated as that of a 60-millimeter mortar with a net explosive weight 1.5 pounds of TNT. Most mortars are not filled with TNT, but rather a mixture called composition B. Composition B is a mixture of TNT and RDX with a small amount of paraffin wax for handling qualities. All different mixtures of explosives must be converted into a TNT equivalency so that they can be accurately compared against one another. For this purpose, we will assume one pound of composition B is equivalent to 1.5 pounds of TNT.

Our current Blastwrap setup can hold two mortars and should be able to attenuate the blast effects safely. With this setup, Afghanistan would require an initial 240 Blastwrap setups.

- Blastwrap two inch thick package in strips (40.5 inches x 10 1/8 inch wide): 2 X $71.25 = $142.50

- 55-gallon industrial plastic trash cans: $55.00

- 5-gallon 3M Fastbond insulation adhesive 49: $290.00

Total cost excluding transport – $487.50 X 240 units: $117,000.00

2. ERW-CP Estimate

Deployment of the ERW-CP kit to Afghanistan would require similar efforts with minor differences. The ERW-CP initial deployment to Afghanistan, to temporarily store the 480 mortar class items, would require 240 ERW-CP since they can hold about the same amount of items. The ERW-CP may also provide a better mechanism to catch the primary frag that is generated when an item detonates. The current kit price runs:

- ERW-CP kit: $2,937.95

The requirement for ERW-CPs is different from that of ERW-CP kits. Theoretically, we could use one kit for all of Afghanistan, but this is not realistic. For the purposes of this research, we consider the map above and initially deploy at least two ERW-CP kits to 22 of the 34 provinces in Afghanistan with the highest levels of incidents.

-Total cost excluding transport: $2,937.95 X 22 Provinces X 2 = $129,269.80

Although the ERW-CP kit has a slightly higher cost, it must be noted that as soon as the Blastwrap has been used from either a detonation or wear and tear, more Blastwrap has to be purchased. The ERW-CP kit is a one-time purchase, as locally sourced the materials can be used to construct more ERW-CPs if the other units deteriorate or are destroyed.

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V. CONCLUSION AND RECOMMENDATIONS

After careful cost comparison analysis, it is clear that an ESM for remote conflict zones like those in Afghanistan and the Philippines is not a good option. The mere size, weight, and logistics of the ESM make this a nearly impractical solution. However, the two alternative options of Blastwrap and the ERW-CP are excellent substitutions that are easily affordable and rapidly deployable to these conflict zones. From the comparative analysis of the two alternatives, Blastwrap has the lower cost and, if in need of quick containment and blast mitigation technology, Blastwrap would be the best choice.

If, however, personnel on the ground desire a long-term relationship between the U.S. and possible allies the ERW-CP is a better solution due to the recurring benefits from papercrete engineering possibilities. This technology not only reduces the presence of explosive device contamination in the area, it also has the capability of creating an economy based upon papercrete construction, and its dual use cannot be overlooked when considering long-term projects to help reduce ERW in the world.

Further analysis should be conducted on the ERW-CP kit as further design improvements come online that may reduce the costs of the kit to be equal to or less than a Blastwrap option. In addition, an individual nation or regional economic analysis on the impact of a papercrete market in an Afghanistan or the Philippines area may provide greater information on the reception of papercrete and the challenges that the market may face.

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